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EGG PRODUCTION AND SELECTION

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ABOUT three years ago breeding for increased egg production was begun at this station with Rhode Island Reds. A report on some of the chief features of the work will be published in the near future, but because of the recent discussion in this journal, by Pearl and Castle, of egg production in relation to selection certain features of egg production in this breed are of particular interest at this time.

The winter record of a hen depends upon two main internal factors aside from possible environmental factors. First, the date at which the first egg of a pullet is produced, which may be taken as an index of the attainment of sexual maturity; and second, the rate of production after the onset of egg-laying. The former in turn depends upon the time when she was hatched and upon her rate of growth. The latter factor, *i. e.*, rate, is controlled in part at least by an internal mechanism. In the Reds it is clear that of the two factors the preponderant effect is exercised by the factor of maturity. The observed differences in rate of production are of less, though by no means negligible importance. In the Barred Rocks, as far as I have been able to learn, conditions are reversed, in that the rate of production appears to exercise a greater influence on the kind of record a hen makes than the age at which she produces her first egg, although the latter is also a factor. Identical records as expressed in number of eggs per unit of time may therefore result, but it is clear that they are not directly comparable. The use of the age at first egg as a criterion of sexual maturity involves some difficulties, but it is the best objective criterion readily available and corresponds at least roughly with the general bodily conditions familiar to poultrymen as indications of the attainment of maturity. These conditions may be observed in the male as well as in the female. There is also an apparent tendency on the average for large pullets to make lower records than their smaller sisters, as shown by the negative correlation between high winter egg production and large size, due probably to a longer growth period in the larger pullets.

The relation between age at first egg and rate involves the following points: A pullet that matures late can not give expression to high fecundity, although she may carry the genes for it, but the record of a pullet that matures fairly early will depend upon the rate at which she lays. On the other hand, a zero producer will be also late maturing, judged according to the criterion suggested, because she does not lay until spring, provided, of course, that she was hatched at the proper season. It is obvious of course that a high record bird must mature early in order to make her record, and that in this sense early maturity and high productiveness will go hand in hand, but early maturity of itself does not insure a high record, for early maturing birds may lay poorly and so make a low record. On the other hand, late maturity is bound to insure a relatively low record. In the flock of Reds with which we have had to do there is *comparatively* little difference in the rate of production. In one flock the coefficient of correlation for the time elapsing between the first egg and the 1st of March and the number of eggs laid was calculated and found to have a value of .8612 ± .0132 which must mean that the flock was fairly homogeneous in respect to rate of production. In other flocks there is clearly a negative correlation between age at first egg and winter egg production but the values have not yet been determined. The difference between a pullet that begins to lay December 1 and lays 60 eggs, another the first of January and lays 40 eggs, another that begins the first of February and lays 20 eggs, must be a question of start. The last bird, too, must be essentially different from a bird that begins to lay in November and lays 2 eggs that month, 10 in December, 0 in January and 8 in February, although she lays the same number of eggs as the individual that began February 1. The former is clearly a mediocre producer, the latter a high producer of late maturity.

The flock averages for the past winter, arranged according to the month in which the birds were hatched, are instructive on this point. The mean egg production for the (140) March-hatched birds was 39.8 eggs, for the (172) April-hatched 29.81, and for the (158) May-hatched 18.1 eggs. If the pullets be grouped according to Pearl's classification of zero, 1 to 30 (mediocre), and over 30 (high), there were among March-hatched pullets 6.4 per cent. zeros, 30.0 per cent. mediocre, and 63.6 per cent. high; among the April pullets 11.6 zeros, 37.3 per cent. mediocre and 51.1 per cent. high; while among the May-hatched pullets there were 19.9 per cent. zeros, 58.8 per cent. mediocre and only 21.3 per cent. high. The average winter production for the mediocre and high producers respectively, is for March-hatched birds 17.2 and 54.6; for April 16.6 and 46.2; for May 16.1 and 40.7. In this connection it should be recalled that there is a tendency for the abstract numbers involved to yield similar averages, which are an indication to some extent at least of two genotypes rather than one. Clearly, the time of year during which a Rhode Island Red pullet is hatched plays an important part in determining the class in which a given individual falls.

In general the use of a hen's record expressed in number of eggs per unit of time as the sole criterion of her capacity for egg production seems to us to be essentially wrong. Attention should also be directed to the elements that enter into the make-up of the record. The factor of maturity is not wholly a fecundity factor, though it is closely bound up with egg production and may modify a pullet's fecundity record very considerably. Broodiness is another factor that, although closely associated with egg production, is after all rather of the nature of a separate entity which may or may not be present, but which when present operates to reduce the egg record of a hen very materially. On the average, a hen's record for the broody months is only about 60 per cent. of the same hen's record for the non-broody months. There is always a sharp break in monthly egg production with the onset of the first broody period and as a hen once broody continues as a rule to alternate brief periods of production with broody periods, it follows that the number of eggs laid depends in a large measure upon the number of broody periods.

Our viewpoint in regard to modifying factors for egg production may be observed in morphological as well as physiological characters. Thus, the color, arrangement and length of hair could not be studied in a hairless race, although the genes for color, arrangement and length may actually exist in the germ plasm of the hairless individuals. Variability in part at least is due to the existence of numerous germinal factors which can come to somatic expression only when some other germinal factor is present. Thus, there are several types of rose comb which appear to be due to definite factors that affect only the rose comb. The spike, for example, may be telescoped into the body of the comb. The telescoped condition is clearly inherited but it does not appear in singles of the same family, although there is no obvious reason why the blade should not be telescoped quite as readily as the spike. Before the rose comb can be said to be understood, the various genetic modifying factors involved, their relations to each other, and the mode of inheritance of each must be made out. Any study of selection that fails to take into account such internal modifying factors is incomplete.

There is no question regarding the inheritance of egg production in the sense that certain families make much better records than some other families, though in the Rhode Island Reds the families that make the better records also mature at an earlier average age than those making poor records. Whether or not the mode of inheritance of fecundity in Rhode Island Reds follows Pearl's theory is still uncertain. Since there is great variability in the age at which the first egg is produced and since its frequency polygon indicates, at least up to 305 days, the essential homogeneity of the flock, we are inclined to believe that the Reds are unfavorable material for a solution of this question. More work, however, remains to be done before this point can be cleared up.

On Pearl's theory the continued selection of genetic high producers and the continued use of their sons as breeders should in the long run tend toward an improved egg production, even though individual pedigrees are not kept, as he himself has pointed out.

The rate at which the selection becomes effective depends much on what classes are assumed to be available at the start. In the following discussion it is assumed that the matings are made on a scale sufficiently large to permit the various matings to take place in the proportions indicated. The scale required, however, is so large that it would be scarcely practicable to test the matter experimentally.

In the first place, it should be pointed out that of the nine genetic classes of males possible on Pearl's theory, classes 5, 6 and 9 are not produced by any mating of class 1 and 2 females—the only classes laying 30 or more eggs—with any class of males. Moreover, it can be shown that if these three classes be assumed to be the only males available and that if only class 1 females ($l_1 L_1$, $L_2 l_2$) be bred throughout the test and if the male offspring be bred in each generation in the same proportion in which they were thrown by the preceding generation, at about the seventh generation there would be male classes 1, 3 and 7 only, existing in the proportion of 1:2:1. Classes 2, 4 and 8 would indeed be present, but the three classes together would amount to only a little over 1 per cent. of the population. This small percentage decreases one half in each succeeding generation. The females produced by this group of males mated to class 1 females only, would occur in the proportion of "over 30" females 75 per cent., "under" 25 per cent. The ratio 1:2:1 among the males maintains itself after once reached, so long as class 1 females only are used for mates.

The same ratio is reached if it be assumed that all nine classes of males exist in equal numbers at the start and that they are bred in each generation in the proportions thrown by the preceding generation and only to class 1 females.

The assumptions made have been chosen as those most likely to lead to decreased egg production or to a maintenance of production on a level. I have not worked out many of the possible assumptions, but as long as only females belonging to classes 1 or 2 are used in the matings, males of higher classes, *i. e.,* classes 1, 2, etc., are thrown by those of the lower classes in the same manner as pointed out for classes 5, 6 and 9, so that eventually males of the higher classes come to exist in definite ratios.

If class 2 females ($L_1 L_1 L_2 l_2$) only are bred, somewhat different results are secured. If males belonging to classes 1, 2, 3, 4, 7 and 8 are used in equal proportions at the start (classes 5, 6, 9 being omitted for reasons stated above) then in the seventh generation nearly 98 per cent. of the males will belong to class 1, the other 2 per cent. belong to classes 2 and 3, and these will diminish one half in each succeeding generation. The final result, then, should be a race of high producers.

Since it has been shown that when class 1 females are used exclusively in the matings, that eventually a stable flock of birds is produced in which male classes 1, 3 and 7 exist in a definite ratio, and since if class 2 females are bred exclusively a flock consisting solely of high producers will result in time, and since class 1 females mated to males of classes 1, 3 and 7 throw 25 per cent. class 2 females, 50 per cent. class 1 females and 25 per cent. mediocre producers, it would seem inevitable that eventually a homozygous race of high producers should result from the continued breeding of the sons of high producers to high producers.

Since Pearl has repeatedly stated that his results apply to annual production as well as winter production, it might be supposed that selection during the Gowell régime should have been effective. Pearl has interpreted the results as due to Gowell's failure to use the progeny test. Two other possibilities, however, suggest themselves. Under the Gowell régime the males came from 200-egg hens, but all hens laying over 150 eggs were used as breeders. Possibly the latter value is too low. The annual production corresponding to the 30-egg division-point for winter production has not been stated, as far as I know, but since the mean annual value of a flock of high producers is stated by Pearl to be about 166 eggs, 150 eggs would seem sufficiently high to exclude mediocre producers. The possibility, then, that this value is too low may be disregarded.

The second possibility relates to the number of males used. In an actual experiment only a relatively few males are used each year. The scale at which the Gowell experiments were carried on was hardly sufficient to equal more than one or two years' work on the scale that would be required to get the males in something like the proportions expected, and hence little or no change in egg production could be expected in the period during which the mass selection experiments were carried on.

While, theoretically, mass selection should be effective under the conditions stated, it would require large numbers in order to be uniformly successful. The progeny test, on the other hand, produces results quickly and definitely.